S
622.342
L3LME

Phillips County Library
10 South 4th St East
Malta, MT 59538

SUPPLEMENTAL
ENVIRONMENTAL ASSESSMENT

for

Zortman Mining Inc.

Application for Amendment No. 010 to

State Operating Permit No. 00095 and

Federal Plan of Operations M-77779

Landusky Mine Expansion

Sullivan Park Heap Leach Pad

Operating and Reclamation Plan

prepared by

Montana Department of State Lands
and
U.S. Department of the Interior
Bureau of Land Management

Pursuant to the

Montana Environmental Policy Act
and the
National Environmental Policy Act

January 25, 1991

Montana State Library
3 0864 1006 3353 9

TABLE OF CONTENTS

CHAPTER I - INTRODUCTION 1
A. Purpose and Need 1
B. Background 1
C. Related Actions 5
D. Agency Roles and Responsibilities 7
1. Department of State Lands 7
2. Bureau of Land Management 7
3. Department of Health and Environmental Sciences (DHES), Water Quality Bureau 7

CHAPTER II - EXISTING ENVIRONMENT 9
A. Climate 9
B. Water Resources 9
1. Surface Water 10
2. Groundwater 11
a. Overview 11
b. Sullivan Park Leach Pad Site 11
C. Geology 12

CHAPTER III - PROPOSED ACTION AND REVISED IMPACTS ASSESSMENT . . 13
A. Mining Plan Description 13
B. Monitoring Plan 15
C. Reclamation Plan Description 16
1. Degradation of Cyanide Compounds (Neutralization) 16
2. Liner Perforation 17

CHAPTER IV - STUDY METHODS AND RESULTS SUMMARY 18
A. Background 18
B. Study Objectives 19
C. Heap Decommissioning Data Review 20
D. Pilot Study and Heap Excavation 20
E. Rinsing and Degradation 21
F. Risk Assessment 21
G. Study Conclusions 22

CHAPTER V - REVISED IMPACTS ASSESSMENT 23

CHAPTER VI - CONCLUSIONS 25

CHAPTER VII - CONSULTATION AND COORDINATION 26
A. Agencies and Organizations Consulted 26
B. Distribution and Review of this EA 26
C. Individuals Responsible for the production of this EA 26

CHAPTER VIII - REFERENCES 27

CHAPTER IX - GLOSSARY 28

LIST OF FIGURES

Figure 1. General Project Location Map 3
Figure 2. Location Map of Landusky Mine Facilities 6
Figure 3. Sullivan Park Leach Pad Liner System 14

CHAPTER I - INTRODUCTION

A. Purpose and Need

This supplemental environmental assessment (EA) has been prepared by the Montana Department of State Lands (DSL) and the Bureau of Land Management (BLM), Lewistown District Office, to evaluate supplemental data submitted by Zortman Mining Inc. in response to Stipulation No. 9 of their permit for Amendment 10. The agencies will use the information in this EA and in the application and related documents, as well as public input, in order to determine whether to approve, approve with modifications, or deny the loading and leaching activities proposed for the Sullivan Park pad. In addition, the Interior Board of Land Appeals (IBLA), in a December 19, 1990 decision document, directed the BLM to determine whether to prepare a supplemental EIS after completion of the study ordered by Stipulation No. 9. The BLM will use this document to make that determination.

Stipulation No. 9 required:

> Zortman Mining, Inc., must undertake a study to research the following:
>
> a. Cyanide concentrations and specific moisture retention in the heaps after neutralization;
> b. Development of blind-offs within the heaps and their effect on heap neutralization;
> c. Infiltration rates as they relate to reclamation practices;
> d. Rates of natural cyanide degradation occurring over time in neutralized heaps; and
> e. Long-term seepage from reclaimed heaps to identify volumes, concentrations of metals and cyanide, and rates of natural cyanide degradation and metal attenuation which would occur following release of the solution.
>
> This study, developed in consultation with the agencies must be done concurrently with existing mining operations and must be completed prior to beginning ore loading on the Sullivan Park pad. Study results will be used to determine the need for modification to the approved reclamation procedures or additional environmental analysis. Additional written authorization must be received from the agencies prior to commencing ore loading of the Sullivan Park Leach Pad.

This supplemental EA will address only those issues related to loading and leaching of the Sullivan Park pad. This EA supplements the May 11, 1990, document and as such the documents should be read together to form a complete package.

The original application for Amendment 10 was submitted in order to allow Zortman Mining, Inc., (ZMI) to continue mining of gold and silver ore reserves in the Landusky area

of the Little Rocky Mountains. The amendment issued allowed for the construction of the Sullivan Park ('91) leach pad but precluded any ore loading and leaching on the pad until the data required in Stipulation 9 was evaluated and an opportunity was provided for public comment. This supplemental EA documents the analyses of the impacts of approval of the loading of ore and its leaching on the Sullivan park pad. The effects of the proposed expanded operations and reclamation plan were previously evaluated in the agencies' EA dated May 11, 1990, and the addendum with responses to comments dated June 22, 1990. These documents are incorporated by reference. These documents also addressed certain cumulative impacts of past, present and future oxide ore mining.

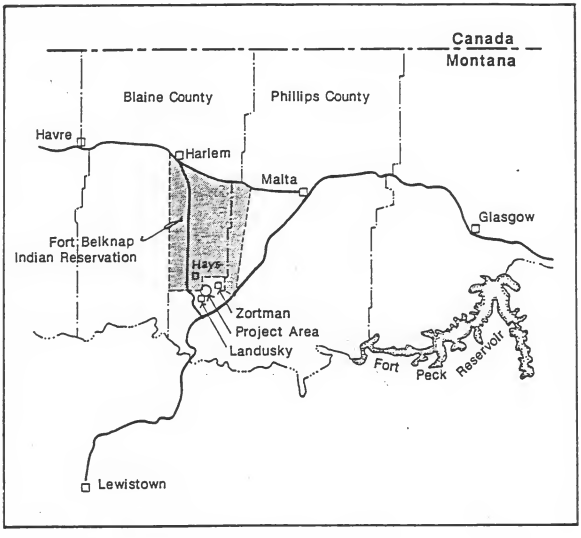
Two public scoping meetings were held on the application for Amendment 10: In Malta on March 14, 1990, and in Hays on March 26, 1990. Approximately 140 and 75 people, respectively, attended the meetings. The meeting in Malta drew a large crowd of mine employees, local business interests and county government. This meeting was very supportive of the mine, and emphasized the positive economic benefits that have resulted from mining in the area. The meeting at Hays was held at the request of the Fort Belknap Tribal Council on the Fort Belknap Indian Reservation. The audience attending voiced concern over possible impacts to water quality on Reservation lands and potential decline in area wildlife populations. Several comments were also made regarding the religious significance of the Little Rocky Mountains, though no detailed areas of concern were identified by the audience. In addition to the two scoping meetings discussed above, three public informational meetings were held on the Fort Belknap Reservation after the EA was released -- one at Hays and one at Fort Belknap Agency on May 22, 1990, and one at Lodgepole on May 23, 1990. The agencies also held two public hearings to accept public comments on the EA -- one in Lodgepole on June 6, 1990, and one in Malta on June 7, 1990.

The issues identified through agency review and public meetings and are addressed in the EA on amendment 10. The identified issues included (1) Sullivan Park heap leach pad stability and liner integrity. (2) heap neutralization, (a) slope reclamation feasibility, (b) long-term cyanide seepage, (c) off-site contamination, (3) water rights, (4) wildlife, (5) visual resources (6) Native American religious concerns, (7) social, economic resources, and (8) cumulative impacts. The issues addressed in this EA on stipulation 9 are limited to rates of natural cyanide degradation in the heap and the potential affects of potential long-term seepage of cyanide out of the Sullivan Park pad.

B. Background

ZMI of Zortman, Montana, a wholly-owned subsidiary of Pegasus Gold Corporation, operates the Landusky gold mine in the Little Rocky Mountains of central Montana, Phillips County (Figure 1). ZMI's state Operating Permit No. 00095 was originally issued June 6, 1979, in accordance with the Montana Metal Mine Reclamation Act (MMRA). That permit application was evaluated in an Environmental Impact Statement (EIS) prepared by the Department of State Lands (DSL) in 1979.

Figure 1. General Project Location Map



Mining has been active in the Little Rocky Mountains southwest of Malta, Montana, periodically since the late 1800's. The Zortman Mining Company has operated a gold mine since 1979. Ore is mined from open pits, and is placed on a plastic (PVC) and clay-lined "heap leach pad" to extract the gold from the ore. In heap-leaching, gold ore is sprinkled with a weak cyanide solution which dissolves the precious metals. The solution percolates through the ore and is collected by the liner. The collected process solution is piped to a plant where the gold is recovered, and solution is recycled back to the heap. Heap leaching uses cyanide to extract gold from the ore in a "closed circuit" where solution is recycled and reused many times over.

Since the original permit was issued, the total permit area has increased from the original 530 acres to 1,287 acres, including the proposed action (Figure 2). Inside that permit area 814 acres was approved for disturbance under amendment 10. This acreage can be divided into the following categories:

leach pads	284.5 acres
pits	214.5 acres
haulage and access roads	76.5 acres
plant facilities	13.0 acres
waste rock dumps	104.5 acres
liquid waste land application	70.5 acres
containment dikes and ponds	32.5 acres
storage areas	9.0 acres
stockpiles	9.0 acres

There are now 8 active and decommissioned heap leach pads on site and 3 pits where mining has occurred or is occurring. Pits are primarily located on patented claims owned by ZMI, while heaps and other facilities are located on unpatented claims where BLM is the surface owner.

ZMI submitted an application for Amendment 10 on May 12, 1989, to continue and extend mining operations. The original permit has been previously amended nine times since 1979. The reader is referred to preliminary environmental reviews and environmental assessments completed by the agencies for those amendments. These documents are on file at the Department of State Lands office, Helena, and the BLM District office, Lewistown, and are summarized in Table 1.

Table 1. Amendments to Permit 0095 and Plan of Operations M-77779

Amendment No.	Date	Purpose
001A	1980	Increase permit area to 276 acres
001B	1982	Increase permit area to 530 acres, increase disturbance to 163 acres

002	1982	Permit Montana Gulch heap, Increase disturbance to 194 acres
003	1983	Montana Gulch - Increase disturbance to 251 acres
004	1984	Montana Gulch - Increase disturbance to 383 acres
005	1985	Montana Gulch - Increase disturbance to 487 acres, permit area to 730 acres
006	1985	Queen Rose Pit Expansion - Increase Permit to 830 acres
007	1986	Mill Gulch Leach Pad
008	1988	Mill Gulch Waste Rock Dump
009	1990	Mill Gulch Leach Pad expansion
010	1990	Sullivan Park Leach Pad

In Amendment number 10, ZMI proposed to process and mine remaining oxide ore reserves on the Landusky side of the Zortman-Landusky mining operation. Operating plan changes or additions included: construction of another heap leach pad (Sullivan Park), extension of an existing heap leach pad (the active Montana Gulch pad), development of access and haul roads, relocation of the Merrill-Crowe processing facilities to a different location within the permit area, addition of a land application system to handle neutralized cyanide process solutions, and an updated reclamation plan for the entire permit area.

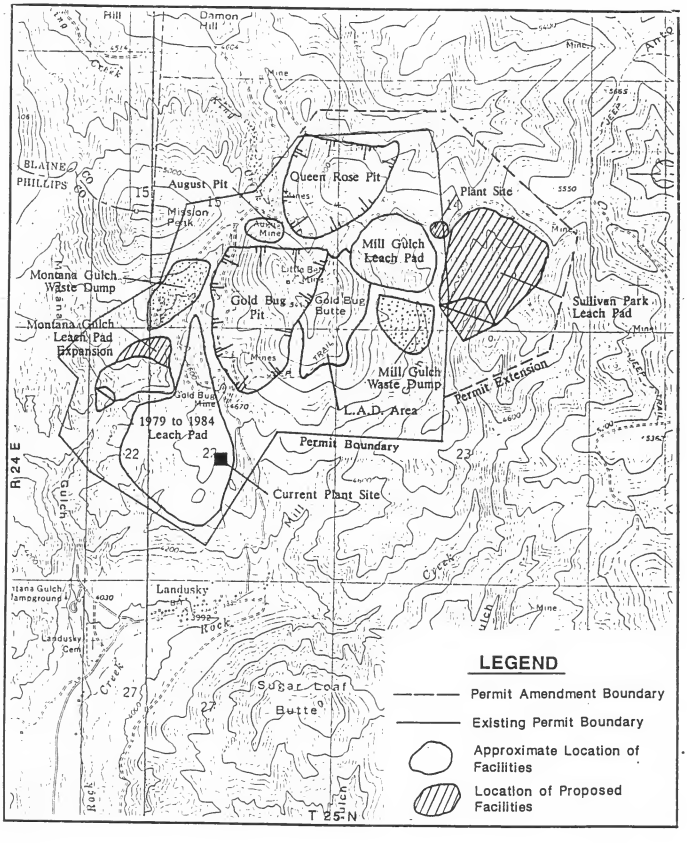
The need for these additional leach heaps and expanded ore processing facilities resulted from ZMI's 1988 delineation of additional reserves. This plan takes into account optimum projections for these oxidized ore reserves.

The ore would continue to be mined on a seasonal basis at a rate of approximately 1,200,000 tons per month. All of the ore in the foreseeable future would come from previously permitted active mining areas which would be expanded and deepened. All other aspects of the operation would use existing facilities except as noted above.

C. Related Actions

The long-term plans of ZMI beyond this EA may include the development of sulfide ore reserves in the Zortman and Landusky area. ZMI is now in the process of developing the baseline information for a sulfide reserves application. The agencies have not received an application for the sulfide project. A plan of study for development of the baseline information was filed. However, the extent of the project and specific disturbances are unknown at this time. As a result, the detailed impact analyses of expanded mining will not be evaluated until the application is received. The agencies would conduct the appropriate

Figure 2. Location Map of Landusky Mine Facilities



environmental analyses (probably an EIS) when an application is received. No part of the potential sulfide ore development is addressed in the EA for Amendment 10 or this Supplemental EA.

No additional mining, timber, or recreational activities are proposed and under consideration by the agencies at this time and therefore, these types of activities are not discussed in this supplement. Related activities which have been addressed under cumulative impacts include ongoing pit development and the existing heap leaching at both the Zortman and Landusky mines.

D. Agency Roles and Responsibilities

1. Department of State Lands

The Commissioner of State Lands must decide whether to approve Zortman Mining's proposed loading and leaching plan as applied for, approve the plan with stipulations, or deny the plan, as required by the Montana Metal Mine Reclamation Act (MMRA) Title 82, Chapter 4, Part 3, MCA.

The Department of State Lands (DSL) administers the MMRA. The purpose of the act is to recognize and protect the usefulness, productivity and scenic values of the lands and waters within the state and to reclaim to beneficial use the lands used for mining. The Act and its regulations (ARM 26.4.101 et seq.) set forth the steps to be taken in the issuance of an operating permit for and the reclamation of the applicant's proposed mine expansion. The Act applies to private, federal and state lands within Montana.

DSL's rules (ARM 26.2.601 et seq.) implementing the Montana Environmental Policy Act (MEPA) (Title 75, Chapter 1, MCA) also require preparation of an environmental assessment. The Department has determined than an Environmental Assessment (EA) is appropriate for this project. This EA is being prepared to document the agencies' analysis of the long-term impacts of loading and leaching ore on the Sullivan Park pad.

2. Bureau of Land Management

The Bureau of Land Management (BLM) is responsible for preventing unnecessary or undue degradation of federal lands, from activity authorized under the Mining Laws, and under regulatory provisions in 43 CFR 3809. Federal regulations (43 CFR 3809.3-1) provide for a joint federal-state regulatory program. Such a program was initiated on April 30, 1984, by a Memorandum of Understanding (MOU) between the BLM and DSL. Under the MOU, both agencies have participated in the review of this amendment. The BLM has responsibilities under the National Environmental Policy Act (NEPA), similar to DSL's MEPA responsibilities, and numerous applicable Executive Orders and Congressional Acts. This EA will fulfill those NEPA responsibilities.

3. Department of Health and Environmental Sciences (DHES), Water Quality Bureau

A Montana Pollutant Discharge Elimination System (MPDES) permit must be obtained before any discharge to surface water may occur. The MPDES permit contains water quality limitations and requires self-monitoring of effluent by the permittee. Mining operations must also comply with Montana groundwater standards. ZMI currently holds an MPDES Permit. No amendments to that permit have been proposed at this time.

CHAPTER II - EXISTING ENVIRONMENT

The mine is located in Phillips County, in the Little Rocky Mountains of north central Montana. Malta is approximately 50 miles northeast and Lewistown is approximately 110 miles southwest. The Missouri River is approximately 22 miles southeast. Elevations in the Little Rockies range from 3,600 feet on the prairie to about 5,700 feet on the highest central peaks. Overall topography is rugged with some slopes exceeding 100 percent. The geology is complex, including sedimentary rock and granitic intrusions which have been subjected to faulting and folding through time. Gold deposits were first discovered in 1893, and sporadic mining activity occurred until the present development.

Comprehensive environmental baseline studies (resource data collections) were conducted in 1978 at both the Zortman and Landusky operations as part of the original hard rock operating permit (00095). Since that date, numerous additional baseline studies have been conducted of water resources, soils, wildlife and vegetative communities of the area. This section of the EA describes environmental conditions associated with the current permit area and those areas that would be included in the proposed expansion (Figure 2).

Resource discussions in this EA supplement are limited to leach pad construction, operation and reclamation issues. Other resource components do not relate to the scope of this supplement and were addressed in the May 11, 1990, EA or the EA addendum of June 22, 1990.

A. Climate

Climatological records of the area have been summarized by Culwell and Ramsden (1978) from data collected for the Zortman and Hays townsite areas. A mean annual precipitation of 19.2 inches at Zortman and 14.3 inches at Hays were recorded. At Zortman, 34 percent of the annual precipitation occurs during May and June, 22 percent during July and August, and about 30 percent occurs as annual snowfall (October through April). One storm event of 5.6 inches occurred in September 1986 and another of 6.0 inches occurred in May 1988. Higher elevations of the Little Rocky Mountain area receive additional precipitation.

The average monthly temperature at Zortman varies from 17.2° F. in January to 67.1° F. in August, with an annual mean temperature of 41.7° Fahrenheit. The frost-free season averages 70 to 100 days from June through early September.

B. Water Resources

Surface waters in the area include Rock Creek, Mill Gulch and its tributaries, and Montana Gulch, all of which are ephemeral in their upper reaches. Water quality is good to excellent except for 3 miles of stream below the Gold Bug Adit discharge, which joins with the Montana Gulch streamflow. Montana Gulch is a tributary to Rock Creek which is a tributary of the Missouri River, 22 miles to the south.

Landusky mining area hydrology has been investigated and described in previous publications by Feltis (1983), Botz and Gartner (1978), Alverson (1965), the Montana Department of State Lands EIS (1979), and in subsequent Landusky Permit Amendment Applications (1983, 1985 and 1986). Considerable additional water resources information has since been collected by Hydrometrics Inc., and Zortman Mining, Inc. as part of operational monitoring programs conducted since 1977. Monitoring has included the collection of flow and water quality data from surface and groundwater sources within and peripheral to the permit area from 1977 to the present.

1. Surface Water

Most of the proposed heap leach pad area and heap water recovery system would be in the Rock Creek drainage. Surface monitoring sites include flow measurement and water quality sampling of streams, seeps and springs in the Rock Creek drainage. During the fall of 1988, Hydrometrics' baseline monitoring activities included a surface flow reconnaissance of the proposed Sullivan Park leach pad site in the upper Rock Creek drainage. Surface flows in the Rock Creek drainage are in response to spring snowmelt and intense rainfall events. Surface water flows in the upper drainage area are ephemeral with the exception of three sites. Results of the surface water investigation identified three sources of water at the proposed heap site. These sources are: a small surface flow of less than 1 gpm in the drainage in the upper portion of the site; an adit seep from previous mine workings approximately 750 feet south of the present BLM access roadway; and a small pond with no visible inflow or outflow at the site of the proposed heap leach pad dike.

Surface water flows in the lower Rock Creek drainage downstream of the proposed Sullivan Park leach pad show streamflows up to 1500 gpm during the spring season with flow rates diminishing throughout the summer and fall seasons. Due to streambed permeability in Rock Creek and Mill Gulch Creek significant recorded streamflow differences exist between stations. Surface flows in the Rock Creek and Mill Gulch drainages at and above the Rock Creek/Mill Gulch confluence infiltrate the permeable Madison Limestone. Downstream of this site, the stream is dry nearly all the time. Observations during fall baseline monitoring periods show that lower Rock Creek monitoring stations are generally dry or have considerably lower flow rates than during spring runoff. Water at two of three sources in upper Rock Creek is a soft, calcium-bicarbonate type with a low total TDS and somewhat elevated concentrations of metals. The water from the old adit location contains elevated concentrations of iron, manganese and arsenic, as does the water issuing from the Gold Bug adit to the southwest.

Typical water quality data for surface flows in the lower drainage show the water is a hard, slightly alkaline, calcium-bicarbonate type with low to moderate concentrations of metals, and TDS.

2. Groundwater

a. Overview

Occurrence and distribution of groundwater in the Landusky area is closely related to both local and regional geology. Regionally, groundwater resources are influenced by several geological units, including syenite porphyry (the host rock for gold deposits), limestone, dolomite, sandstone, Precambrian metamorphic rocks and alluvial deposits. Syenite porphyry and Precambrian metamorphic rocks are the common rock types found in the proposed permit amendment areas. Faults, joints and fractures are the principal paths for groundwater recharge and movement in these units in the Little Rocky Mountains. Small quantities of groundwater can usually be obtained from wells drilled into bedrock. Most domestic water wells near Landusky are located either in town or on nearby ranches and are derived from unconsolidated alluvial deposits or shallow limestone or sandstone less than 200 feet deep. Several springs are present in alluvium and provide small flows in many drainages. Numerous springs are present around the entire base of the Little Rockies and are related to local and regional stratigraphy and structure.

On a local scale, the general groundwater movement in the mine area north of the existing monitoring network and above the 4,550-foot elevation is probably towards the Gold Bug adit. Near the Gold Bug adit, numerous mine workings are present and water-bearing zones and fracturing exists. The water associated with mines in the Landusky and Zortman areas suggests the subsurface water system is interconnected over a substantial area and is now being drained by the Gold Bug adit at the 4,500-foot elevation. Flow from this adit shows significant response to seasonal precipitation trends. Adit flow in the early 1980's declined from that observed in earlier years as a result of lower than normal snowpacks and rainfall. Adit flows observed in these years generally ranged 150 to 400 gpm. As a result of higher than normal rainfall in the fall of 1985 and spring 1986, adit flow in June 1986 was observed to be over 1,000 gpm. The Mill Gulch and Sullivan Park heaps are located above the 4,600 elevation.

Domestic water supplies in the Landusky area depend entirely upon groundwater, obtained either from wells or springs which are derived from unconsolidated alluvium, or shallow limestone sandstone. The Gold Bug adit discharge provides a relatively constant flow to Montana Gulch. Small springs in Mill and Montana Gulches provide some water to some segments of these drainages. One spring in Mill Gulch previously has been used as a domestic water supply. However, most small springs throughout the area are unused. Past mining operations used groundwater from the Gold Bug adit for ore processing. The present ore processing operations also would continue to use this adit water.

b. Sullivan Park Leach Pad Site

The area of the Sullivan Park heap is considered to have two groundwater systems -- a shallow alluvial system and a bedrock system. Both systems flow to the south. A shallow groundwater system exists in alluvium in the Rock Creek drainage bottom. In the heap area, the alluvium is absent in some segments of the drainage. The alluvial groundwater system is discontinuous due to the lack of continuity of the alluvium. The coarse-grained sediments

comprising the alluvium seasonally drain in segments of the drainage and contain groundwater only after recharge by snowmelt or precipitation. Due to the ephemeral character of the drainage, a potentiometric map of the alluvium was not prepared. Water table contours in the alluvium would reflect the topography of the drainage bottom with a gradient essentially the same as the drainage bottom.

Bedrock in the Sullivan Park heap area contains groundwater. Similar to bedrock in other drainages in the Landusky area, the groundwater system is fracture controlled and groundwater is only encountered where fractures are present. Thirteen of 26 test holes drilled 200 feet deep did not encounter groundwater. The other 13 wells hit groundwater with yields ranging from less than 1 gpm to over 5 gpm. These values are typical of a low permeability bedrock aquifer. Based on water levels in the 13 test holes that encountered groundwater, a potentiometric map was prepared that showed the groundwater system is controlled by the topography of the drainage with a relatively steep gradient parallel with the direction of the drainage. Based on test hole water yields, it is estimated that transmissivities in the bedrock range from nearly zero to a maximum of a few hundred gallons per day per foot. These are low transmissivities and they reflect the limited fracturing present in the bedrock. The flux of groundwater in the bedrock is small, probably not exceeding 15 gpm for a 1,000-foot wide section of the bedrock.

C. Geology

The Landusky area is classified as a Zone 1 earthquake risk, indicating the possibility of only minor damage potential due to an earthquake. The only significant earthquake of record occurred in 1968 at a distance of 77 miles with a magnitude of 5 (Richter Scale) and would have produced a horizontal acceleration at the site of approximately 0.01 g.

In the proposed expansion area, the bedrock consists of Tertiary intrusive syenite porphyry, trachyte porphyry and Pre-Cambrian quartz-feldspar gneiss and amphilbolite schists. Exposed bedrock units in the drainage below the leach pad sites include Paleozoic, Mesozoic and Cenozoic sedimentary formations of limestones, sandstones and shales.

CHAPTER III - PROPOSED ACTION AND REVISED IMPACTS ASSESSMENT

This chapter describes the construction, loading and leaching of the Sullivan Park pad and the projected impacts of the plan. This impact analysis supplements that presented in the May 11, 1990, EA and is based on supplemental data collected in response to Stipulation 9.

A. Mining Plan Description

The proposed action to be implemented would be that discussed as the Preferred Alternative in the May 11, 1990, EA. This includes incorporation and continuation of the mitigation measures stipulated in the June 22, 1990, permit approval.

The Sullivan Park pad would continue to be constructed east of the Mill Gulch pad (Figure 2) and would allow for continued mining of the oxidized ore reserves. The leach pad facility would have a total permitted capacity of 50 million tons and would be up to 400 feet high and 2,000 feet across at its widest point, covering about 100 acres. Distribution of ore depth versus lined area for the Sullivan Park leach pad would be: 0.63 acres overlain by slightly more than 400 feet of ore, 6.5 acres with an ore depth greater than 350 feet, and 14.9 acres overlain by more than 300 feet of ore. The remaining 65 acres would be covered by ore depths of less than 300 feet. Ore placement would begin at the bottom, or lowest point, inside the pad and proceed upward in 25-foot horizontal lifts to maintain stability.

Following removal of vegetation the Sullivan Park heap leach pad (Figure 3) was constructed in stages, as follows:

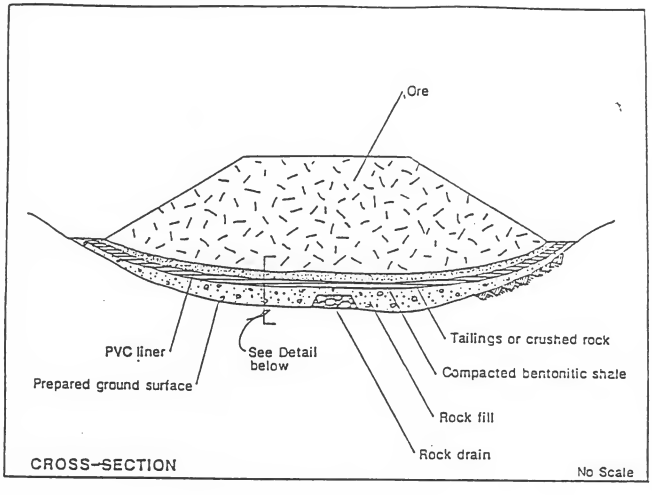
1) Site Preparation: The pad foundation would be stripped of all soil and weathered rock. This would include removal of all vegetation and compressible soil and rock. Approximately 82 acre-feet of soil materials would be salvaged and stockpiled directly to the east of the pad for use in final reclamation.

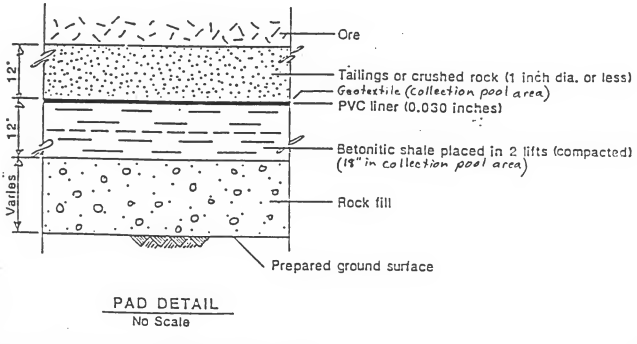
   In addition to preparation of the foundation site, diversion structures would be built around the leach pad, with a capacity to accommodate a 100-year storm event, to avoid erosion and channeling. Off-site sedimentation and soil loss would be controlled by these drainage diversions designed for the life of the mine, with some of the diversions incorporated into the final reclamation plan.

2) Underdrains: Underdrains would be used for drainage beneath the pad and would be constructed by using uniform size rock that would not decompose when repeatedly wetted. This material would be placed in all of the minor drainages underlying the leach pad area, and have a capacity exceeding a 100-year runoff event. The underdrains would exit from under the liner at a common point below the dike.

3) Pad Foundation: The foundation, which would overlay the bedrock and underdrains, would be prepared by cutting or filling certain areas of the prepared site to provide a smooth, sloping, and consistently compacted liner surface.

Figure 3. Sullivan Park Leach Pad Liner System





Cutting operations would consist of drilling, blasting and hauling of material to fill areas until final grade was reached. Fill areas would be constructed using 5-foot lifts of competent rock compacted by construction equipment.

4) Shale Liner: Construction would be in two stages. In Stage 1, a bentonitic shale liner would be laid down after the foundation and dike are completed. The shale would be laid in two compacted lifts of nine inches each in the central portion of the pad area. In Stage 2, the remainder of the liner would be laid down, which would be positioned around the outer perimeter of Stage 1. This bentonitic shale would be laid down in two compacted six-inch lifts.

5) Geomembrane Liner: A geomembrane, or synthetic liner, would be laid over the clay liner. This synthetic liner minimizes loss of solution, and provides for internal solution collection upstream of the dike. ZMI would use 30-mil PVC, with a 10-ounce geotextile on top of the PVC for Stage 1 construction. The stage 2 area would also use 30-mil PVC. ZMI liner installation system consists of laying down PVC in sheets 150 by 70 feet in a shingling method with overlaps of 3 to 5 feet. The overlapped PVC seams are glued in place to provide a continuous seal.

6) Liner Protection: To protect the liner from puncture by large chunks of ore during heap construction, ZMI would place a protective layer, 12 to 18 inches thick, of crushed materials over the entire synthetic liner. This material would consist of material one-inch in diameter or smaller.

7) Dike Construction: A dike would be constructed at the downstream end of the pad site. The dike would serve to keep the ore in place and would be constructed in 5-foot lifts using competent rock material which would be compacted by construction equipment. The down-stream side of the dike would be constructed at a 2h:1v slope and the upstream side at a 2.5h:1v.

8) Contingency Pond: A pond would be constructed, 200 by 100 by 15 feet deep, with a 1.3-million-gallon capacity below the pad. This pond would allow surface water that arrives at the toe of the leach pad dike through the under-drain to be intercepted and returned to the pump-back facility in the event of a leak. The pond would be lined with 12 inches of bentonitic shale and a 36-mil hypalon liner.

B. Monitoring Plan

The proposed water resources and quality monitoring system would consist of a contingency pumpback and groundwater/surface water monitoring system and a 1.3-million gallon contingency pond to contain any contaminated water detected from the underdrain or the pumpback wells. Contaminated water would be pumped from the contingency pond to the Landusky plant. Three additional groundwater monitoring wells would be installed and four surface water monitoring locations established to monitor the groundwater, underdrains and surface water associated with the pad. Two of the groundwater wells (ZL-131 and ZL-

132) would be located to monitor the Rock Creek drainage immediately downstream of the Sullivan Park pad. These wells would be completed with one well drilled and completed into the alluvium, with the second well drilled and completed into the underlying bedrock. The third monitoring well to be installed (ZL-133) would be a bedrock well located at the mouth of the lower Rock Creek drainage.

Four additional surface monitoring locations would be established to monitor surface water flow along the upper Rock Creek drainage. These locations would monitor surface flows from the leach pad underdrain (L-27), upper Rock Creek below the containment pond (L-26), a tributary to Rock Creek (L-28) and upper Rock Creek (L-29).

Groundwater wells ZL-131 and ZL-132 would be monitored weekly, and well ZL-133 would be monitored on a monthly basis. All surface water locations would be monitored on a semi-annually basis. Operational monitoring sites, analytical parameters, and monitoring frequency for the entire Landusky operation are listed in Appendix 2 of the application for Amendment No. 10. Monitoring would be conducted by ZMI with oversight provided by the BLM, DSL and the WQB.

As proposed, the monitoring system for the Sullivan Park pad would be essentially the same as the monitoring system for the Mill Gulch Pad. In the event containment and pumpback operations are initiated downstream of the Sullivan Park heap, at monitoring-/contingency wells ZL-131, 132 and 133, ZMI would drill additional downslope wells to detect contaminant migration and/or contain and reclaim groundwater.

C. Reclamation Plan Description

Reclamation of the Landusky operations would include cyanide process solution degradation, liner perforation of the heap, slope reduction, placement of soil and revegetation of the neutralized heaps, and containment dikes, slope reduction, soil placement and revegetation of waste rock dumps, ponds, roads and facility areas. No pit reclamation is proposed as provided for under the Metal Mine Reclamation Act (82-4-336(7), MCA), except for pit floors which will be ripped, soiled, and revegetated. Only cyanide degradation and liner perforation are discussed here because of their relationship to the issues. The remaining reclamation details are presented in the May 11, 1990, EA and stipulated in the June 22, 1990, approval decision remain unchanged.

1. Degradation of Cyanide Compounds (Neutralization)

Cyanide in the leached ore heaps would be degraded by dilution after completion of ore processing. Fresh make-up water would be circulated to dilute and degrade the cyanide compounds left in the heap. If dilution with water is unsuccessful, the effort would be supplemented by the addition of an oxidizing agent such as hydrogen peroxide. Circulation of the neutralizing solution would be handled through a contingency pond allowing for circulation of neutralizing solution from the pond back through the spent ore heap via spray lines normally used for cyanide solution application.

As required by Stipulation No. 1 to Amendment 10 cyanide neutralization of all spent ore heaps must continue until leachate discharge levels of less than 0.22 mg/l (milligrams per liter) (WAD) cyanide are maintained over a 6-month period which includes a spring snowmelt and runoff.

If chemical neutralization were not required, the resulting solution would be used for make-up water in the ongoing leaching process on active heaps. If chemical neutralization is necessary, the resulting batch of solution would undergo additional treatment to where it would be suitable for sprinkling on forest soils (land application) which attenuate metal concentrations. Neutralized solutions would be land applied when cyanide concentrations have been reduced to 0.22 mg/l WAD cyanide.

2. Liner Perforation

To eliminate precipitation storage and undesirable hydraulic conditions associated with the reclaimed heap leach facility, the pad liner would be perforated once the heap has been neutralized. Six-inch drain holes would be drilled through the heap synthetic and clay liners. Each drain hole would be backfilled with sized rock to an elevation of at least 5 feet above the liner surface.

CHAPTER IV - STUDY METHODS AND RESULTS SUMMARY

The following section summarizes information, methods, and findings of the additional studies required by stipulation 9 to amendment 10. For more detailed information the reader is referred to: Cyanide Degradation and Rinsing Behavior in Landusky Heaps, January 1991. The study plan was developed in consultation with an Ad Hoc Advisory Committee which consisted of representatives from ZMI, the consultants and the agencies, as well as representatives from the Environmental Protection Agency and the US Forest Service.

A. Background

Cyanide is a naturally-occurring chemical found in a number of plants and certain foods. Cyanide, like many compounds, is non-toxic at low concentrations. Cyanide levels of less than 0.22 mg/l in drinking water have been deemed safe by public health officials. Cyanide is toxic if consumed in adequate dosages. Cyanide has been used safely in the mining industry for decades; however, regulatory agencies have required increased protective measures to insure that adequate safeguards are present to protect human health and the environment both during and after mining.

A key to understanding how cyanide can be used safely lies in recognizing its chemical nature (see boxed discussion on Cyanide Forms and Fate in the Environment). While there are many chemical forms of cyanide, only the "free cyanide" form is toxic.

In nature, cyanide undergoes a number of reactions which render it less toxic. Less toxic compounds like thiocyanate and cyanate may form. Cyanide can pass into the atmosphere or be "biodegraded" by a number of organisms. As a result, cyanide does not persist at high concentrations in the environment.

B. Study Objectives

The objectives of the investigation conducted at the Landusky Mine were to provide the information requested by the agencies as a result of analyses present in the Landusky EA. Specific information requested included:

1) Measure cyanide concentration and water content in heaps after neutralization;
2) Identify "blind-offs", if any, within the heaps and their effect on de-commissioning. A blind-off is an area within a heap that cannot be reached by rinsing and will maintain elevated cyanide levels for an extended period of time;
3) How well do growing plants, which increase the evaporation rate of water from soil, reduce the amount of water percolating through the heap;
4) Predict the natural cyanide degradation that will occur within the heaps;
5) Estimate the amount of long-term seepage from the heaps and the cyanide and metal levels in seepage;
6) Estimate the fate of cyanide and metals in seepage from the heaps.

CYANIDE CHEMICAL FORMS AND ENVIRONMENTAL FATE

Cyanide is a simple molecule containing one atom each of carbon, and nitrogen. Cyanide occurs in a number of chemical forms which include free cyanide, and complexes of cyanide. Cyanide complexes form when one or more molecules of cyanide bond with another compound, frequently a metal like iron. The complexes of cyanide are much less toxic than free cyanide and are usually more abundant than free cyanide in mining process water. Most solutions used at mine sites contain 500 milligrams per liter cyanide or 1 pound of cyanide per ton of water. Limited external contact with water containing up to 500 milligrams per liter free cyanide is relatively safe provided the pH of the water is kept basic (pH above 10 to 11).

The quantity of various forms of cyanide in water can be measured using a number of techniques. "Total Cyanide" measures all cyanide in solution including both toxic and non-toxic forms. The "Free Cyanide" test measures only the more toxic free cyanide forms. A third test is called the Weak Acid Dissociable or WAD cyanide test. This, the most frequently used and most reliable test, measures the free cyanide plus the complexes which can easily break down to release free cyanide at an acid pH. The level of WAD cyanide deemed safe for drinking water in Montana is 0.22 milligram per liter, equivalent to 1 part cyanide in 4 million parts water.

Cyanide in solution is readily broken down in nature by a number of chemical reactions and through biological metabolism. Cyanide can volatilize meaning it can pass into the atmosphere as a gas. Cyanide can break down into a number of less toxic compounds like thiocyanate, and cyanate. Various organisms can break down cyanide into ammonium or nitrate and carbon dioxide. As a result, cyanide is seldom observed in the environment at appreciable concentrations. If cyanide is released into the environment it usually degrades or breaks down quickly.

"Neutralization" is the first stage of de-commissioning which involves rinsing a heap which has undergone natural degradation with fresh water to remove additional cyanide. Rinsing is continued until water collected from the spent ore is less than 0.22 mg/l WAD cyanide. A concern expressed in the Environmental Assessment was that the fresh water rinsing would not remove cyanide evenly throughout the heap, thus pockets (called "blind-offs") of heap material with elevated cyanide concentration would remain after rinsing.

The study designed to address these issues consisted of a detailed review of existing information on heap de-commissioning, an excavation through an existing heap to look for evidence of pockets of unrinsed heap material with elevated cyanide levels, a full-scale rinsing and natural degradation study, and computer modeling of the results. An environmental risk assessment was also conducted to identify the risk of cyanide impacts to the environment or human health after mine closure. Each of these phases of the investigation are summarized.

C. Heap Decommissioning Data Review

A number of gold mines in the western U.S. have developed de-commissioning plans for their heap leach operations. Many of these mines, like Zortman Mining, use fresh-water rinsing and natural degradation for cyanide removal. Water used for rinsing is treated to remove cyanide and metals or is re-used for additional rinsing. At the Borealis Mine in Hawthorne, NV, a large heap leach pad that was rinsed for 10 to 20 days achieved WAD cyanide levels of less than 0.2 mg/l. At their Annie Creek Mine in South Dakota, Wharf Resources has successfully rinsed their spent ore in a 60-day period using hydrogen peroxide treatment.

Extensive information on levels of cyanide in drainage from spent ore heaps is available from the Landusky and the neighboring Zortman Mine in the Little Rockies (Schafer et al., 1991. Chapter 4). Cyanide levels in heap drainage progressively decrease as the time since a heap was last leached increases. Most of the heaps monitored have not been rinsed, so the observed decline in cyanide concentration is due to natural degradation. Results from the Landusky study show that the rate of cyanide degradation follows a relationship where the concentration at any time after the end of leaching can be predicted. WAD cyanide levels have a half-life of 80 days for the first 2.5 years. A heap with a WAD cyanide level of 500 mg/l will decrease naturally to 250 mg/l in 80 days, 125 mg/l in 160 days, and 15.6 mg/l in 400 days. The long-term cyanide degradation is somewhat slower with a half-life of 3.4 years. Even without rinsing, spent ore heaps should reach 0.22 mg/l WAD cyanide in 6 to 10 years after the end of leaching.

D. Pilot Study and Heap Excavation

A pilot study was implemented to evaluate equipment performance and installation techniques in the coarse-textured ore material to assure successful monitoring of the cyanide degradation and rinsing study. The pilot study results provided data used to determine instrument suitability, to improve installation techniques, and to verify the effectiveness of installations.

Instruments for measuring water movement and chemical quality of water were placed within a spent ore heap. After a few weeks of instrument observations this section of the heap was excavated to determine the usefulness of the instruments to measure in-place conditions. The instruments used for monitoring the heaps were found to provide reliable data.

The excavated area was visually inspected for the formation of blind-offs, or zones which cannot be rinsed and which contain elevated levels of cyanide. No evidence of blind-offs were detected. Solution applied to the heap was observed to flow downward through the heap rapidly. Compacted layers, or layers impermeable to water, which could slow the rate of water movement in the heap were not observed.

A test was also conducted to determine if ore would break down under a 400-foot high heap potentially leading to formation of fine particles and blind-offs. The test measured

the durability of particles under a load equal to the pressure under 400 feet of material. No ore breakdown was observed.

E. Rinsing and Degradation

After the field reliability of the instruments was verified during the pilot study a detailed investigation was conducted to measure the effectiveness of rinsing with fresh water and natural cyanide degradation in removing cyanide from spent ore. In order to conduct this study process solution was added to a spent ore heap to bring cyanide levels up to those found after leaching. Process solution containing 500 to 700 mg/l WAD cyanide was applied to a portion of an existing heap. The heap selected for study was last leached 11 months prior to this study. The water content and cyanide and metal concentrations within the heap were carefully monitored during application of process solution. One-half of the heap was then fresh-water rinsed while natural cyanide degradation was allowed to proceed on the other half.

WAD cyanide levels in the heap at the start of this study were 15 to 30 mg/l, down from 500 mg/l in the 11 months since leaching. When process solution was added, the cyanide levels increased again to 400 mg/l. Fresh-water rinsing for 10 days reduced the cyanide levels by 50 to 90 percent at the various locations tested. Although the efficiency of rinsing varied from place to place within the heap, natural cyanide degradation was equally active throughout the heap. No zones with higher-than-normal cyanide concentrations were found. Water movement within the heap did not provide any indications of the existence of blind-offs.

Metal levels measured in the heap were highest just after application of the process solution, and decreased naturally as did cyanide.

F. Risk Assessment

An environmental risk assessment was also performed to evaluate the potential threat of long-term metal and cyanide seepage from reclaimed heaps. Risk assessment is an analytical tool widely used to evaluate the potential risk of hazardous chemicals to human health or the environment. A risk assessment involves four steps. The first step is hazard identification in which hazardous chemicals and their characteristics are evaluated to see which constitutes the greatest risk. Cyanide is the compound of greatest concern in the spent ore heaps.

Next an exposure assessment is conducted to see how the cyanide might move from the heaps after closure of the mine, and reach humans or the environment. Before a heap can be reclaimed it must be rinsed until cyanide levels in the effluent are less than 0.22 mg/l, which is the level in drinking water which public health officials have found to be safe. A large rainstorm may cause water containing small amounts of cyanide to drain from the heaps and mix with surface water or groundwater. The exposure assessment uses the computer model developed to identify the concentration of cyanide that may be expected in rivers and groundwater after a large rainstorm. The rainstorm used in the risk assessment would be expected less than once each 100 years. The results predict cyanide concentration in surface

water at 0.037 mg/l and 0.055 mg/l in groundwater. Both of these values are below the standards set by regulatory agencies, and, therefore, the risk of cyanide affecting human health or the environment was found to be small.

G. Study Conclusions

No evidence of blind-off formation was found during the investigation. The movement of water through the heap during solution application suggested that flow was rapid and relatively homogeneous.

Natural degradation of cyanide was observed through long-term records of cyanide in heap effluent as well as through the intensive monitoring of heap solution during the study. The rate of cyanide degradation was fit to a "decay curve" which indicates a general trend in the reduction of WAD cyanide with time, even without any effort at heap rinsing.

Active rinsing with fresh water would accelerate removal of cyanide, metals, and nitrate from heaps. The addition of 1 pore volume of fresh-water rinse reduced cyanide, metal, and nitrate levels by 50 to 90 percent.

Monitoring of HCN gas in samples taken from within the heap suggests that volatilization is the primary degrading mechanism for cyanide.

Soluble metal levels were closely tied to the abundance of cyanide. As the amount of WAD cyanide decreased through natural degradation or rinsing, metal concentrations declined proportionally.

An environmental risk assessment was completed to identify the potential effects of WAD cyanide and metals released from heaps at closure for a 6-inch storm. Predicted levels of WAD cyanide were 0.055 mg/l in groundwater and 0.037 mg/l in surface water at the point of potential exposure. These amounts are well below the health advisory level of 0.22 m/l set for cyanide.

Further information can be obtained in the report entitled "Cyanide Degradation and Rinsing Behavior in Landusky Heaps" prepared by Schafer et al. (1991) and on file at the agencies' offices in Helena, Montana, and Lewistown, Montana.

CHAPTER V - REVISED IMPACTS ASSESSMENT

A supplemental analyses of the cumulative impacts to water resources is presented here. All other resources remain unaffected by the additional data and do not pertain to the issues. Cumulative impacts to other resources were discussed in the May 1990 EA and are incorporated by reference. This section revises and supplements the impacts assessed in the EA of May 11, 1990 and the EA Addendum of June 22, 1990.

The original EA of May 11, 1990, stated on page 99-100 that: "...While the impacts are not believed to be significant, with the mitigation imposed, this cannot be completely demonstrated due to the unresolved technical questions...This does not allow the agencies to categorically state that long-term cumulative impacts of the preferred alternative would therefore not be significant."

The technical questions raised in the EA have been resolved. This now allows the agencies to update their impact assessment with an acceptable level of confidence.

The findings of the study, as summarized in Chapter IV and detailed in the full report, have conclusively shown that impacts to water quality, public health, or other environmental concerns, are not individually or cumulatively significant. The basis for this impact assessment is due to the following points:

1) Specific moisture retention in the heaps is low at 7.4 percent (average), increasing to 8 percent moisture content during leaching. After leaching ceases the moisture content returns to equilibrium within about a week and heap discharge stops. Approximately 10 percent of the pore space volume contains the retained solution. This allows for degradation of cyanide through volitilization to occur in the remaining air-filled pore space of the heap surrounding the retain fluid.

2) There is no evidence of blind-off development in the older heaps at the Landusky Mine and none is expected to develop in the proposed heaps. Therefore both active and passive heap detoxification processes would be able to occur throughout the ore heap at closure.

3) Any cyanide concentrations retained within the heaps after detoxification procedures have ceased will continue to degrade naturally. Even assuming the unlikely retention of full strength cyanide solution in some portions of the heap the cyanide concentration would decline to acceptable levels with 6 to 8 years.

4) There is no threat to public health or the environment by effluent discharge from reclaimed heaps at the Landusky Mine. An environmental risk assessment was completed to identify the potential effects of cyanide and metals released from heaps due to a 6-inch storm event. Predicted levels of WAD cyanide were 0.055 mg/l in groundwater, and 0.037 mg/l in surface water. These amounts are well below the 0.22 mg/l Health Advisory level. Metal levels in cyanide solutions were found to be tied to the abundance of cyanide, as most occur as metal-cyanide complexes. When

cyanide levels have reached the reclamation criteria of 0.22 mg/l, metals in solution are well within the drinking water standards.

CHAPTER VI - CONCLUSIONS

The operator, Zortman Mining Incorporated, has satisfactorily complied with Stipulation 9 by providing the subject study.

No additional modifications, mitigations or stipulations to the state Operating Permit, or the federal Plan of Operations, are warranted by the study findings.

There are no significant impacts or issues requiring additional environmental analysis before loading and leaching may occur on the Sullivan Park and Montana Gulch expansion leach pads.

CHAPTER VII - CONSULTATION AND COORDINATION

The Department of State Lands and the Bureau of Land Management have developed this EA with staff specialists. Public involvement included public meetings in Malta and Hayes, Lodgepole and Fort Belknap Agency, Montana. In addition, a public meeting on this EA has been scheduled for February 21, 1991, in Dodson, Montana.

A. Agencies and Organizations Consulted

Ad Hoc Advisory Committee
Bureau of Land Management
Environmental Protection Agency
United States Forest Service
Montana Department of Health and Environmental Sciences
Air Quality Bureau
Water Quality Bureau

B. Distribution and Review of this EA

Copies of this EA supplement are being provided to about 100 persons, groups, local governments, and agencies which have expressed an interest in the Zortman-Landusky projects. The mailing list was compiled using the names and addresses of parties who participated in public meetings or requested copies of the EA as well as agencies, governments, tribes, and companies potentially affected by this project or who were consulted during preparation of the May 1990 EA.

C. Individuals Responsible for the production of this EA

Claudia Furois, DSL	-	Wordprocessor
Scott Haight, BLM	-	Geologist
Pat Plantenberg, DSL	-	Vegetation Specialist
Pete Strazdas	-	Range Conservationist/Regulatory Program Supervisor
Terry Webster, DSL	-	Hydrogeologist
Bob Winegar, DSL	-	Geologist/Regulatory Program Supervisor
Scott Spano, DSL	-	Soil Chemist/Regulatory Program Supervisor

Reviewers include:

Sandi Olsen, Bureau Chief
Gary Amestoy, Administrator
Gene Miller, Assistant District Manager, BLM

CHAPTER VIII - REFERENCES

Montana Department of State Lands and Bureau of Land Management, May 11, 1990. Environmental Assessment for Zortman Mining Inc. Application to Amendment No.010 to State Operating Permit No. 00095 and Federal Plan of Operations M-77779, Landusky Mine Expansion - Sullivan Park Heap Leach Pad, Operating and Reclamation Plan.

Montana Department of State Lands and Bureau of Land Management, June 22, 1990. Addendum to Environmental Assessment for Zortman Mining Inc. Application to Amendment No.010 to State Operating Permit No. 00095 and Federal Plan of Operations M-77779, Landusky Mine Expansion - Sullivan Park Heap Leach Pad, Operating and Reclamation Plan.

Schafer and Associates, and EIC Corporation, January, 1991, Cyanide Degradation and Rinsing Behavior in Landusky Heaps.

CHAPTER IX - GLOSSARY

2h:1v	Slope angle measurement; slope is twice as long horizontally as vertically; 2h:1v = 27°; 2.25h:1v = 24°; 3h:1v = 18°
ACEC	Area of Critical Environmental Concern
AQB	Air Quality Bureau, Department of Health and Environmental Sciences
BLM	U.S. Bureau of Land Management
DHES	Montana Department of Health and Environmental Sciences
DNRC	Montana Department of Natural Resources and Conservation
DSL	Montana Department of State Lands
EA	Environmental Assessment - an environmental document of a proposed action and its effects on the environment. Required by the federal National Environmental Policy Act (NEPA) and the Montana Environmental Policy Act (MEPA).
EIS	Environmental Impact Statement - an environmental document delineating a proposed action's effects on natural and human environment. An EIS gives an in-depth look at specific issues and cumulative effects in an area. Required by the federal National Environmental Policy Act (NEPA) and the Montana Environmental Policy Act (MEPA)
ESA	Federal Endangered Species Act
FOS	Factor of Safety: A ratio of the forces resisting failure to the forces promoting failure. A FOS of 1 means the forces are equal. FOS greater than 1 imply stability.
gpd	gallons per day
gpm	gallons per minute
heap	a pile of oxide ore prepared for leaching
LAD	land application disposal
LCY	Loose Cubic Yard
mg/l	milligrams per liter

mil	one one-thousandth (1/1000) of an inch
pad	lined, waterproof base on which an ore heap is placed
pH	measure of the acidity or alkalinity; 7 in neutral, low numbers are acidic
PLS	Pure Live Seed
PMP	Probable Maximum Precipitation
ppm	parts per million
ppt	parts per thousand, with reference acid-base potential; this commonly expressed in tons of $CaCO_3$ per thousand tons of material
PSD	Prevention of Significant Deterioration
PVC	Polyvinylchloride
TDS	Total dissolved solids
TSP	Total Suspended Particulate
USLE	Universal Soil Loss Equation
WAD	Weak Acid Dissociable - method of measuring chemically active cyanide
WQB	Water Quality Bureau, Department of Health and Environmental Sciences
ZMI	Zortman Mining, Inc.